Status of the XENON Direct Dark Matter Detection Experiment

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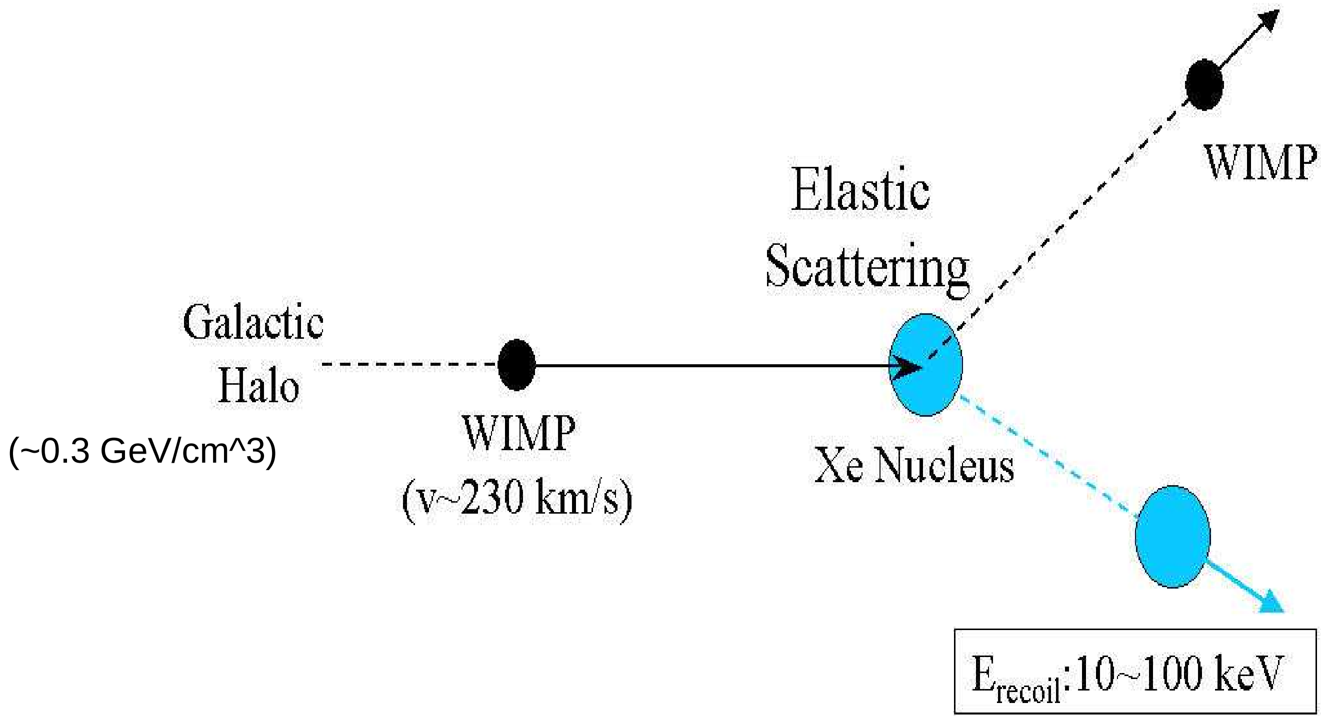
The Dark Matter Problem

Most of the mass of the universe appears to be in Cold Dark Matter (CDM).

Weakly Interacting Massive Particles (WIMPs) left over from the big bang are good candidates for the CDM.

We expect WIMPs to be in a spherical halo centered on our galaxy.

Direct Detection via Nuclear Recoil



Current and Projected Limits

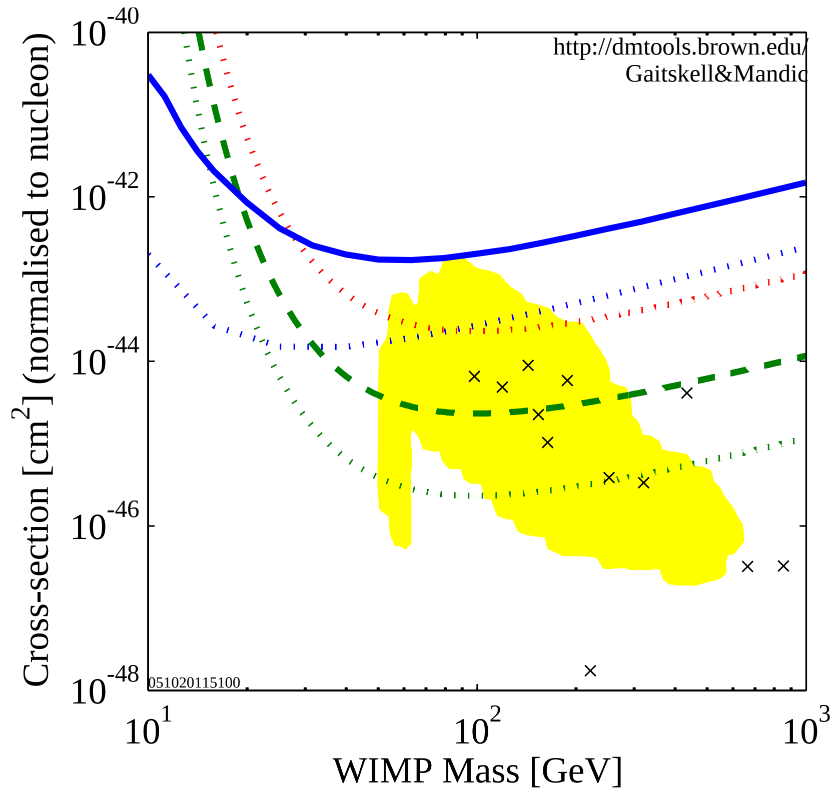
Current limits
~300 events/10 kg/month

Projected XENON10 limit
~2 events/10 kg/month

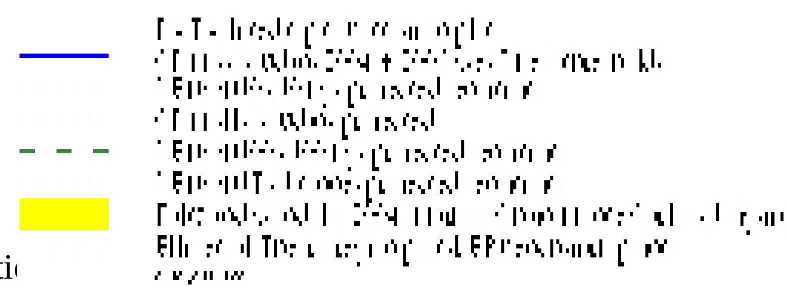
SUSY parameter space requires ton scale experiments

Liquid noble gas detectors easy to scale

Spin independent $\sigma \propto A^2$



CDMS II
XENON 10 projected
CDMS II projected
XENON 100 projected
XENON 1T projected



XENON Objectives

<u>1 ton of target LXe</u>

*scintillation and ionization for particle ID
*3D event localization for fiducial cut
*16 keV threshold
* 99.5% gamma rejection

<u>Background lower than 0.001 count/kg/keV/year</u>

*material screening
*active veto
*passive shield

<u>Phase 1: XENON 10</u>

*10 kg target mass
*operating within 2006 at LNGS
*expected sensitivity 2WIMP events / 10 kg /month

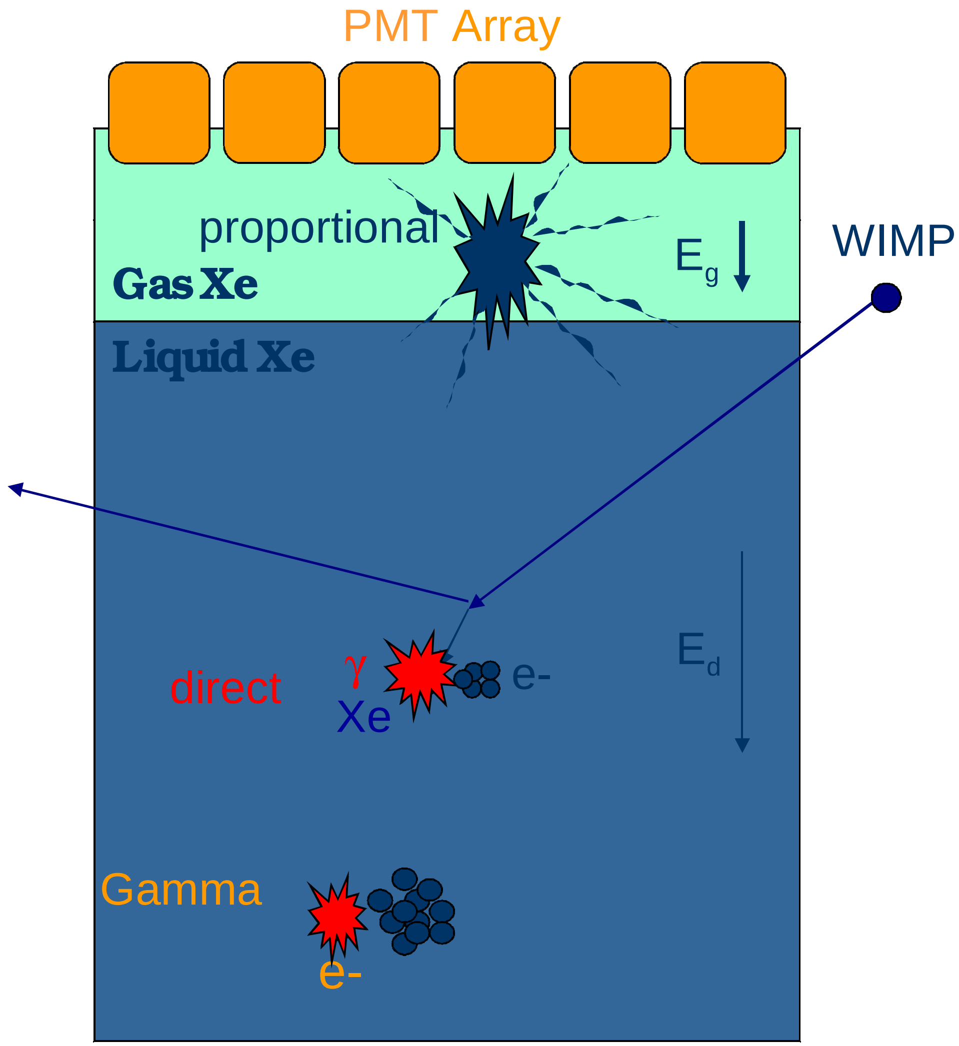
<u>Phase 2: XENON 100</u>

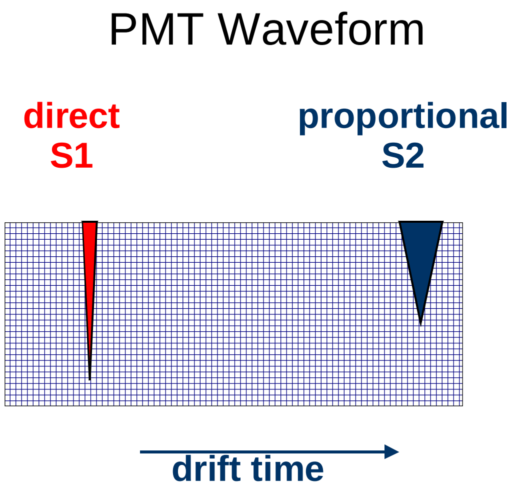
*operational in 2008

<u>Phase 3: XENON 1T</u>

*depends on results from Phase 2 and other experiments
*world wide collaboration
*deeper lab

Basic Principles of Operation





Gamma background rejection

$(S2/S1)_{wimp} << (S2/S1)_{gamma}$

Fiducial volume cut

Horizontal from S2 PMT hit pattern

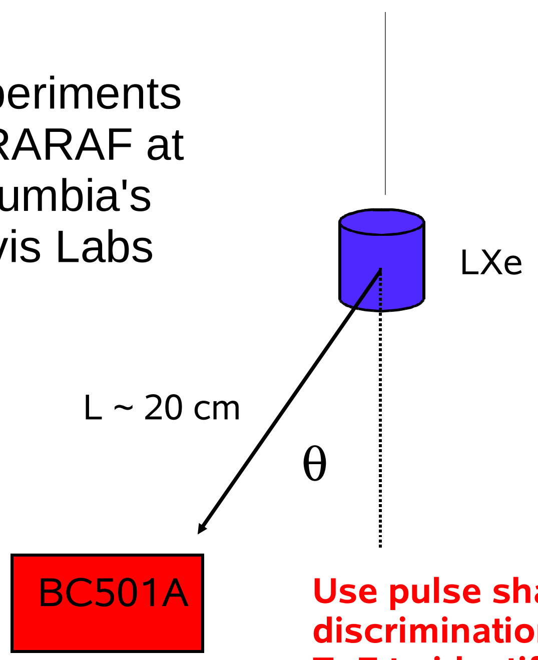
Vertical from S1 to S2 timing

Threshold: Nuclear Recoils

$$E_r = E_n \frac{2 M_n M_{Xe}}{(M_n + M_{Xe})^2} (1 - \cos(\theta))$$

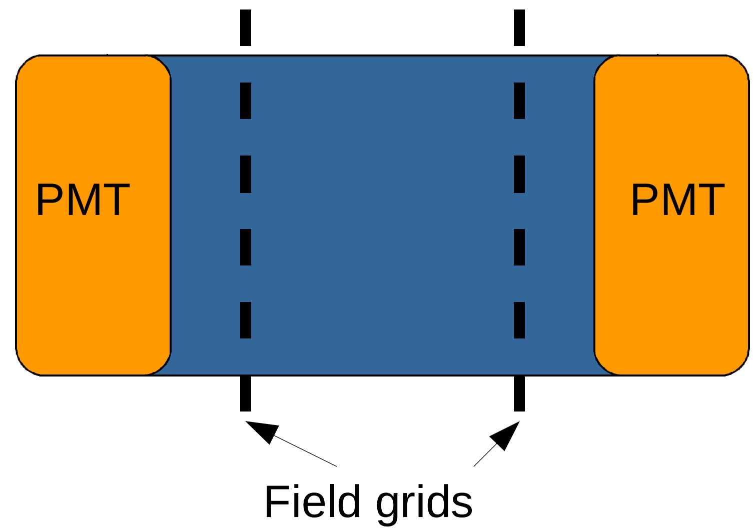
p(t,^{3}He)n
2.4 MeV n

Experiments at RARAF at Columbia's Nevis Labs



Use pulse shape discrimination and ToF to identify n-recoils

Nuclear recoil efficiency measured with a single phase primary scintillation only cell



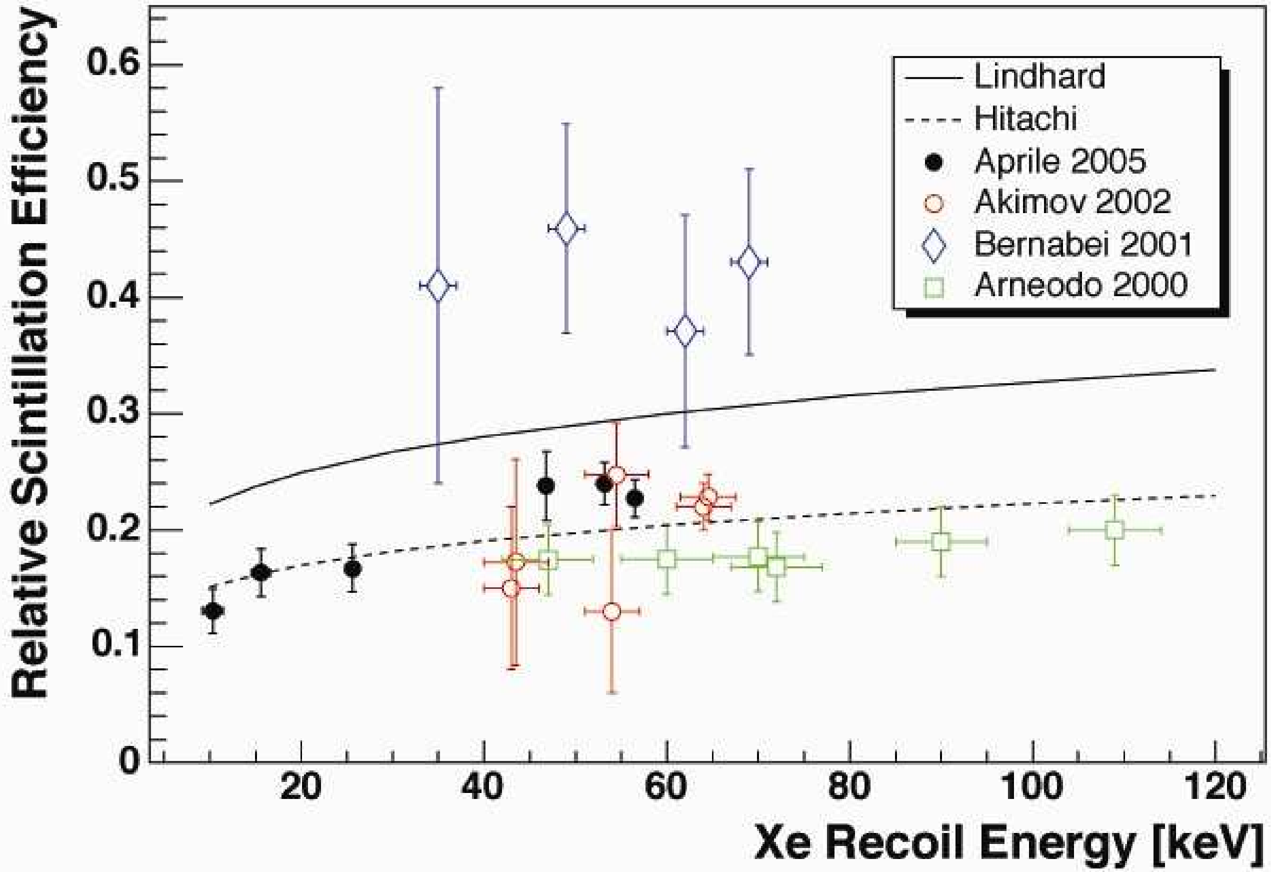
Field grids also allow investigation of scintillation efficiency as a function of field

Threshold: Nuclear Recoils

Needed light yield from NR at low energies and with field

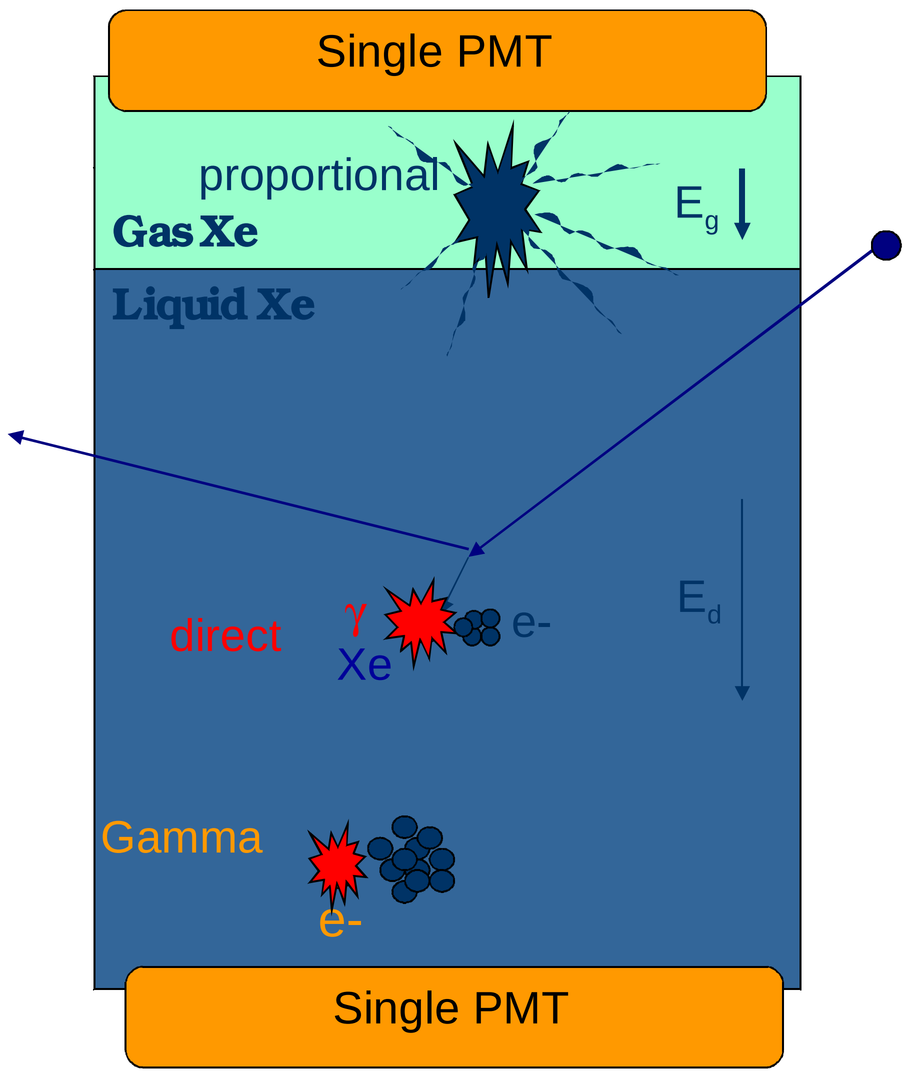
Reduced efficiency at low energies expected

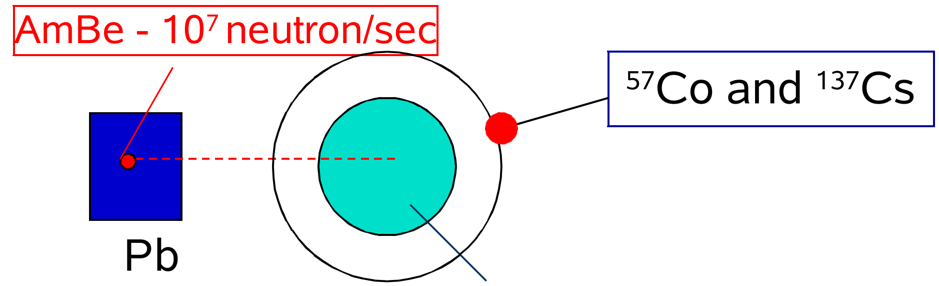
- Low velocity reduces efficiency of exciting electrons
- Interactions in track

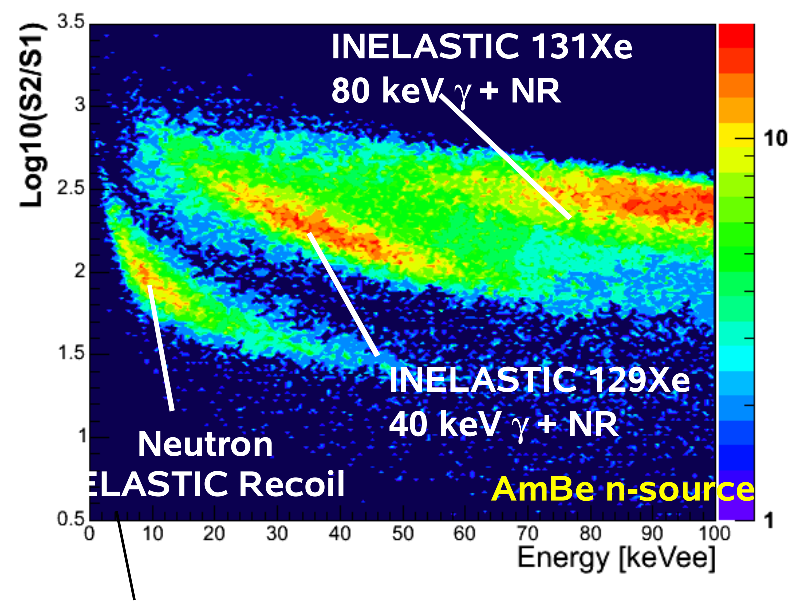


E. Aprile, Phys. Rev. D 72, 072006 (2005)

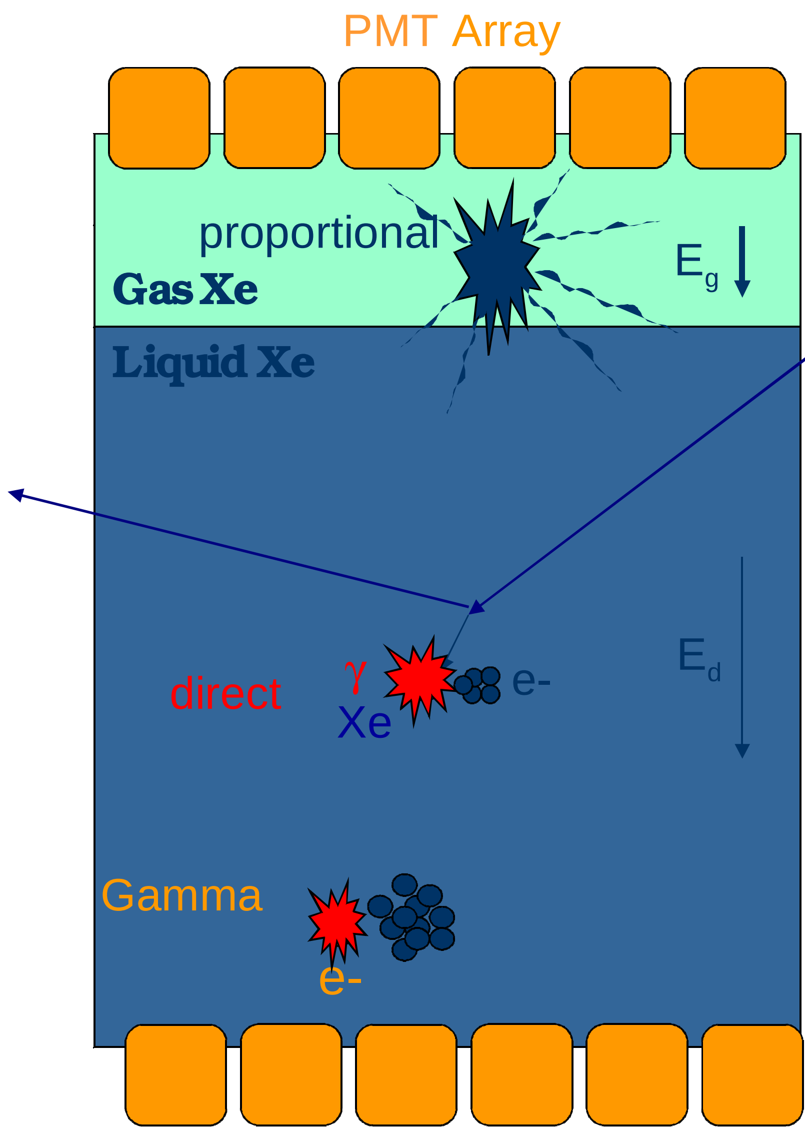
Event Discrimination

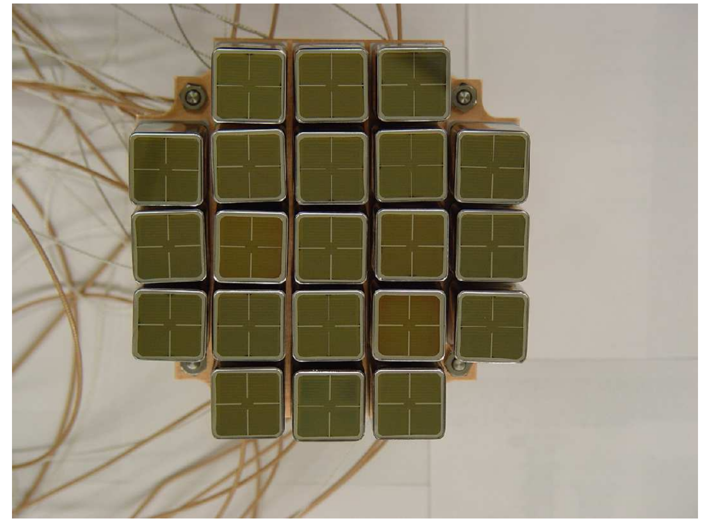






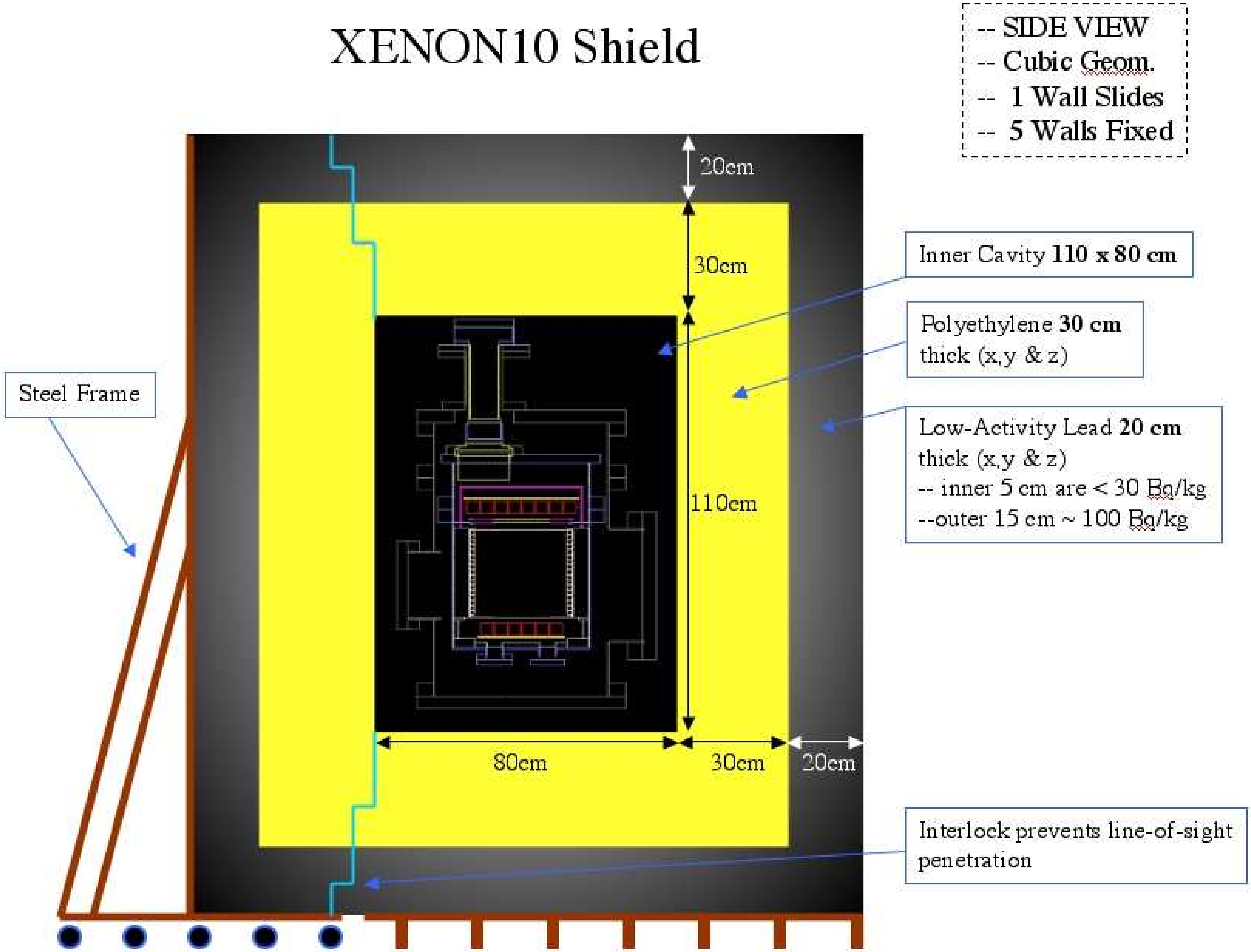
10 kg Detector





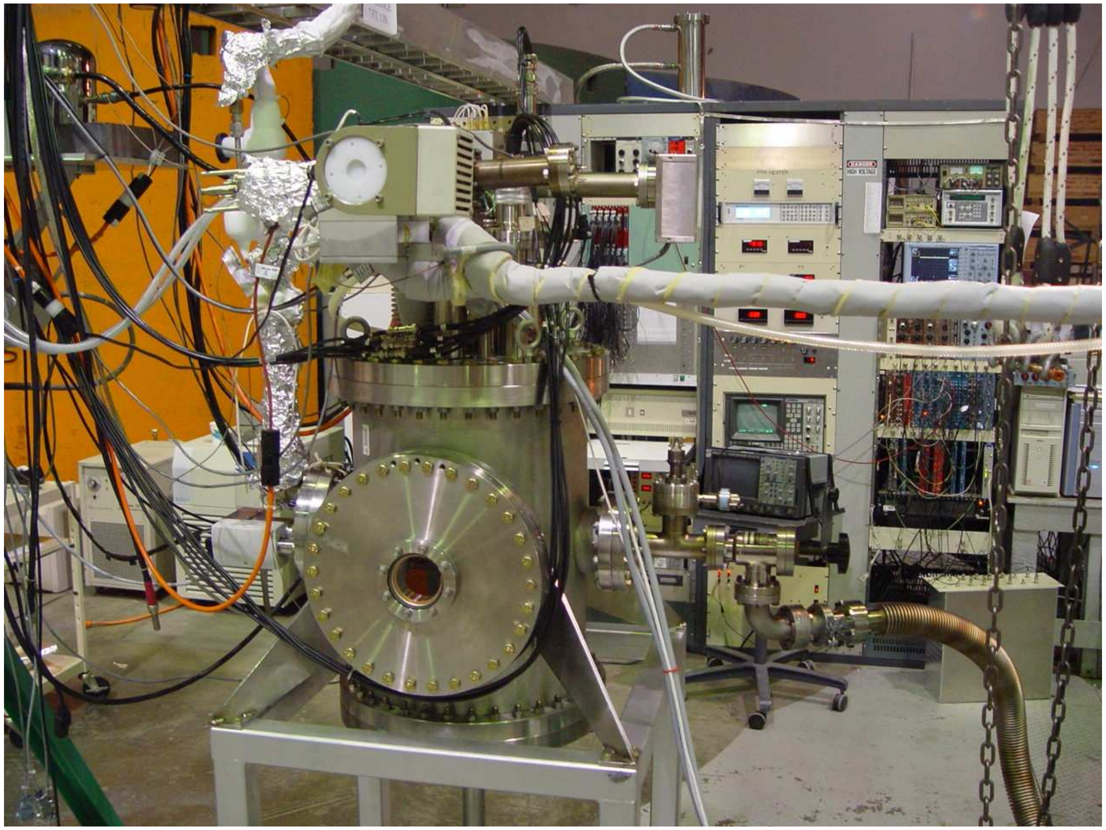
- Metal Channel, compact ((2.5 cm)^{2}x3.5cm))
- Square anode (good fill factor (66.2%).
- Low background : ^{238}U / ^{232}Th = 15 / 3 mBq
- Quantum Efficiency : >20 % @178nm

10 kg Detector



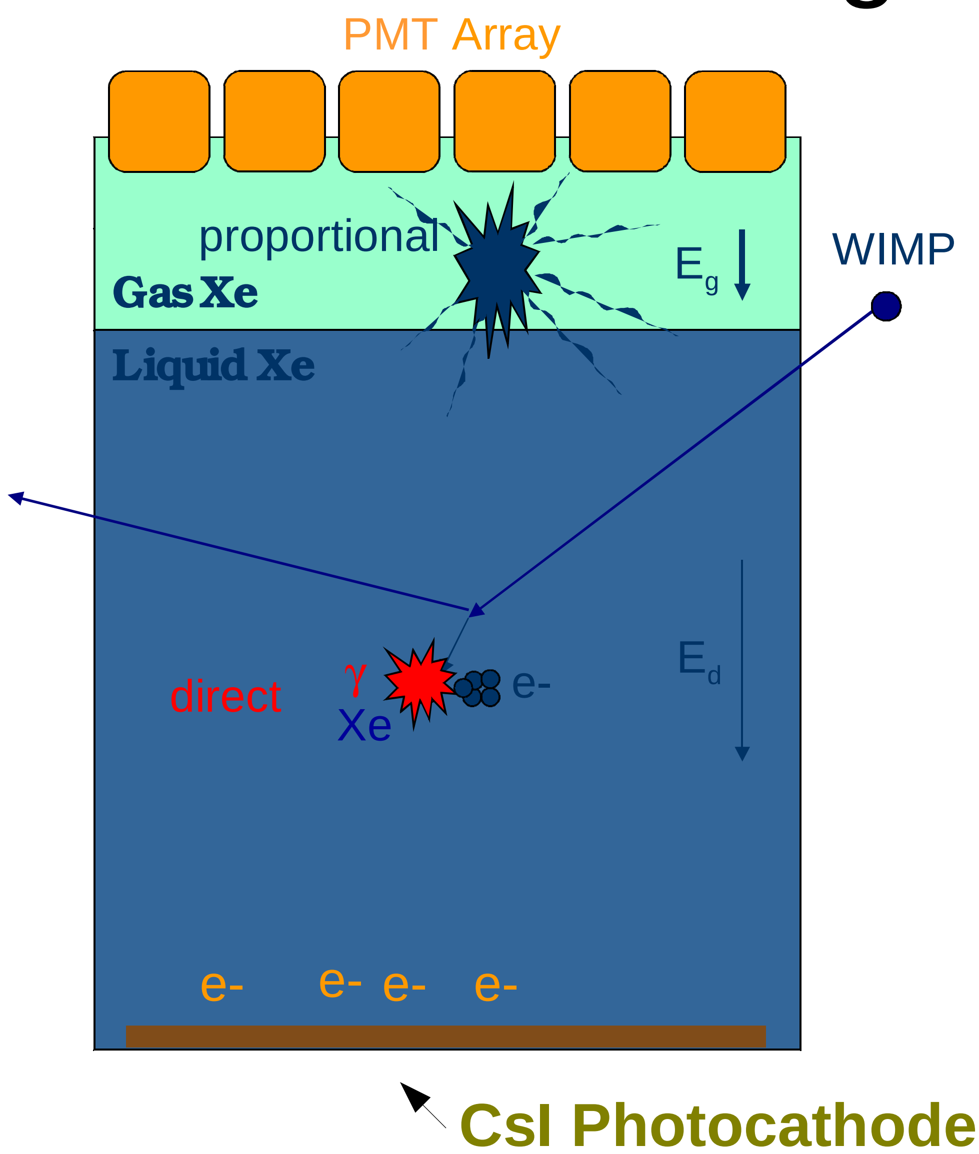
XENON 10 Completion Plan

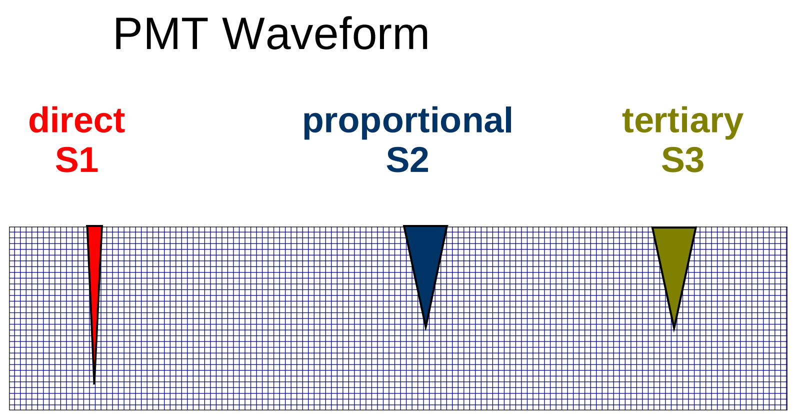
+ Kr removal for XENON10	in progress
+ Background Simulations	in progress
+ Materials Screening for XENON10	in progress
+ Design of XENON10 system	detector/DAQ/Shield commissioned



Science runs expected to begin Spring 2006.

Threshold: Light Collection CsI





A tertiary signal can be generated from absorbing primary photons by CsI photocathode in LXe:

- **Large Area/ Low Radioactivity/Low Cost**
- **100% coverage with high QE**

~20% @ 3 kV/cm

Aprile et al. NIMA 338(1994)
Aprile et al. NIMA 343(1994)

Collaboration Achievements

* Low activity PMTs operating in LXe
* Greater than 1 meter λ_e in Lxe
* CsI photocathode in LXe w/o Feedback
* Operating ~few kV/cm electric field
* Electron extraction to gas phase
* Efficient & Reliable Cryogenic System
* Electron/Alpha recoil discrimination
* Nuclear recoil Scintillation Efficiency (10-55 keVr)
* Nuclear recoil Ionization Efficiency
* Electron/Nuclear recoil discrimination